Aachen Graphene & 2D Materials Center

2D Materials and Quantum Device Group | RWTH AACHEN UNIVERSITY

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Bachelorarbeit:

Energy-resolved ultrafast optical micro-spectroscopy

Motivation: Electronic processes typically play out on timescales of several femtoseconds (10^{-15} s) to few picoseconds (10^{-12} s). To resolve such processes in time, methods are needed which themselves are faster than the processes to be measured. This can be achieved using ultrashort laser pulses: first, a pump pulse starts the process (by exciting electrons), and a second, precisely timed, probe pulse takes a snapshot of the sample at the time delay between the pulses. This process is then repeated for different time delays. In this thesis, such an optical pump-probe experiment is supposed to be expanded to be able to collect spectral information in parallel, which will allow to measure data with a high signal to noise ratio.
Experiments to be performed with such a technique will focus on exciton (electron-hole pair) dynamics in monolayers and heterostructures of transition metal dichalcogenides (TMDs). These are two-dimensional (2D) semiconductors, with promising properties regarding novel types of data processing (valleytronics) and for flexible electronics.

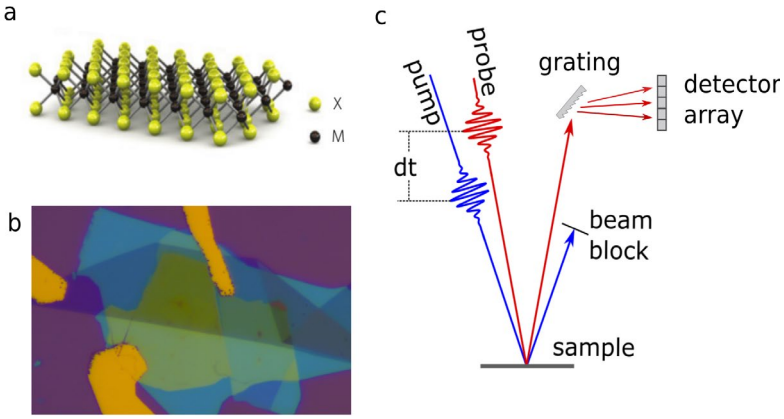

Fig. 1: a) Sketch of the crystal structure of a TMD monolayer. b) Microscope image of a typical heterostack of a TMD include a graphite backgate. c) Sketch of the measurement system

Goal of the thesis: The aim of this bachelor thesis is to measure the dynamics of excitons in a TMD monolayer using optical pump-probe spectroscopy. The main work will be setting up an experiment for parallel and broadband optical pump-probe measurements.

Your tasks: Your task will consist of building a setup for optical pump-probe spectroscopy including electronic work on the detector array. Furthermore, you will work on the preparation of heterostructure samples via exfoliation of 2D materials. The production of your samples will be performed in our laboratories, including our clean room facility. For the optical experiments, you will have access to our laser laboratory, in which you will set up the experiment. You will also be able to expand your knowledge in the following topics:

- Working with state-of-the-art semiconductor manufacturing technologies in cleanroom research facilities
- Various optical spectroscopic techniques
- Operation and understanding of vacuum and low-temperature (~10K) setups
- Consolidation of your knowledge about the fundamental physics of electronic bandstructures, 2D materials, physics of excitons and simple electronic componentsYou will also take part in group seminars and journal clubs to discuss current developments in this field of research.

Contact: For further information and interest please contact Lutz Waldecker (waldecker@physik.rwth-aachen.de). You can also find information on our work at www.stampferlab.org and www.graphene.ac.